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A preliminary study on the overwintering of *Pelopidas mathias* (Fabricius) (Lepidoptera, Hesperiidae) in the northern Kanto region, central Japan

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Abstract I observed overwintering larvae of the small branded swift, *Pelopidas mathias* in Tsukuba, Ibaraki Prefecture during the winter of 2006–2007. Larval density was highest in a sunny grassland situated by the wall of a building. In this environment, the larval food plant, *Imperata cylindrica* maintained green leaves throughout the winter, and larvae were active on warm days. Even in February, at an overwintering site that was exposed to the direct rays of the sun, the daily maximum temperature sometimes reached approximately 30°C whereas the minimum fell to near 0°C. Larvae that were collected in the field in early April and kept in an outdoor cage successfully developed and emerged in mid May-early June as adults. These larvae molted zero to three times before pupation. The pupal period was 22–35 and 16–21 days when the pupation took place in April and May, respectively. Moreover, one adult female was caught by a Malaise trap set in the grassland near the building in mid May. From the results of the present study, larvae of *P. mathias* seem to be able to pass the winter in inland fields of the northern Kanto region, at least when the winter is mild.

Key words *Pelopidas mathias*, larva, overwintering, *Imperata cylindrica*, diurnal range of temperature, Ibaraki prefecture, emergence season, pupal period.

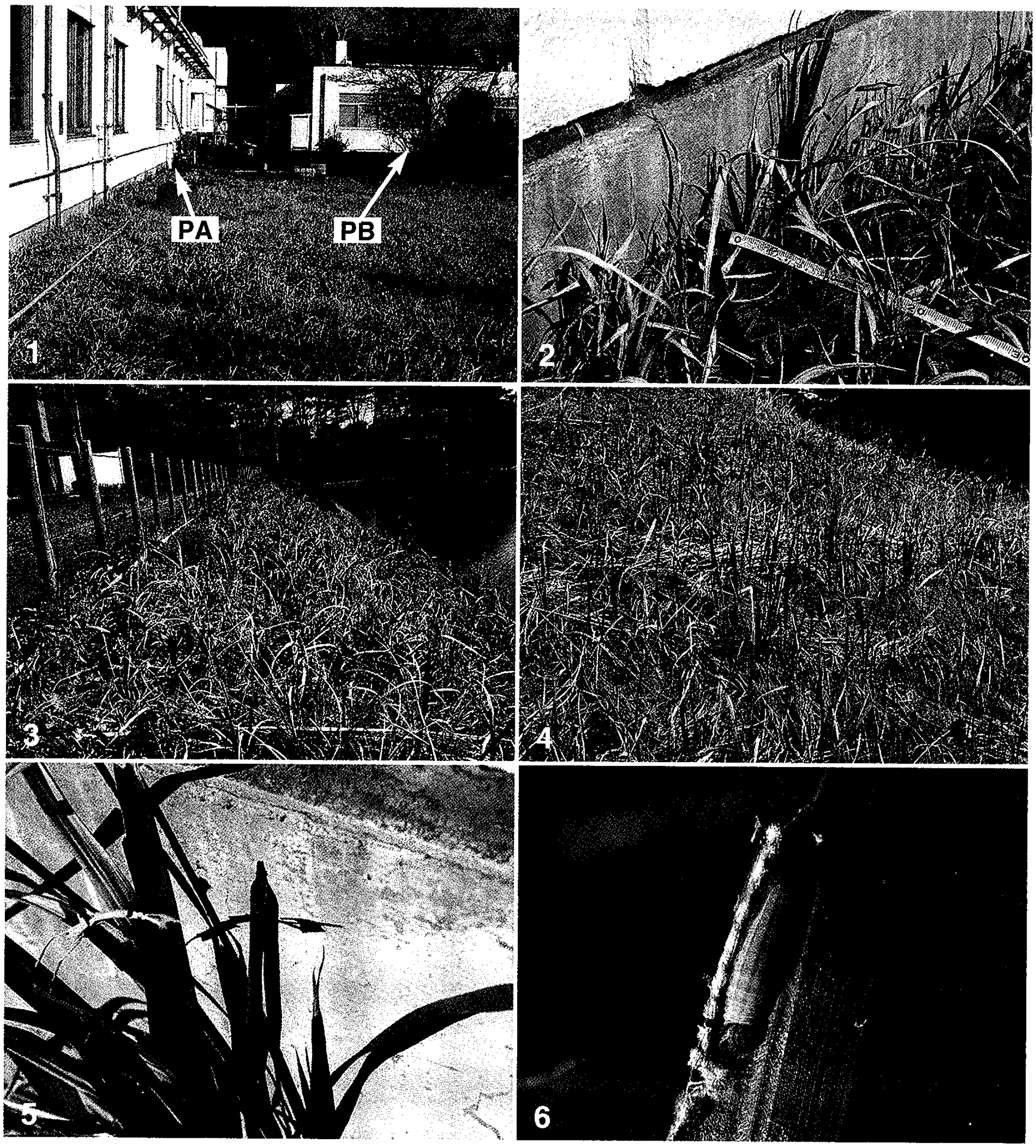
Introduction

The small branded swift, *Pelopidas mathias* (Fabricius), is a multivoltine skipper, with hibernation occurring during the larval stage. In Japan, the species is resident in southern Honshu, Shikoku, Kyushu and the Nansei-Shoto Islands, and migrants reach northern Honshu in autumn. It is assumed that *P. mathias* larvae can pass the winter in the warm temperate regions of southern Kanto and southward along the Pacific Ocean (Fukuda *et al.*, 1984; Shirôzu, 2006). I observed a lot of overwintering larvae during the winter of 2006–2007 in Tsukuba, an inland city of Ibaraki Prefecture, northern Kanto. Adult emergence was confirmed by two methods, rearing of larvae and trapping of adult skippers. This paper reports on the results of these studies.

Materials and Methods

Larval density in the field

I observed overwintering larvae of *P. mathias* in the field of the Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Ibaraki Prefecture, central Japan (36°00′N, 140°08′E, 25 m a.s.l.), from December, 2006 until May, 2007. This field is *ca* 45 km away from the nearest coast. I chose three sunny grasslands as the study sites. Site A was located on the south side of a concrete building and included two quadrats. The quadrat A-1 (18.5 by 0.8 m) abutted the wall and A-2 (18.5 by 4.0 m) was adjacent to A-1. A strip of concrete (*ca* 12 cm in width) formed the boundary between A-1 and A-2. There was no pent roof, but metal tubes existed above quadrat A-1 (Figs 1 and 2). Site B was located between a pond and a thin pine forest and included one quadrat (quadrat B; 18.5 by 4.0 m; Fig. 3). Site C was located on a south slope of a small hill and included one quadrat (quadrat C; 18.5 by 4.0 m; Fig. 4).



Figs 1–4. Photographs of the site A, B and C on early February, 2007. 1: Site A (quadrat A-1 and A-2). PA and PB indicate the points where the temperatures were recorded. PA (Point A): inside the grasses growing by the wall of a building. PB (Point B): in the shade of a tree at 1.5 m above the ground. 2: A close-up picture of quadrat A-1. 3: Site B (quadrat B). 4: Site C (quadrat C).

Figs 5–6. A larval nest and an overwintering larva of *Pelopidas mathias* found near the building in early February, 2007. 5: A nest made by an old larva. 6: A mid instar larva.

At all three of the sites, the grass was mowed in September of 2006, and after that, regrowth appeared. Cogon grass *Imperata cylindrica* (Gramineae), one of the major larval food plants, dominated these sites during the winter. I counted the number of *P. mathias* larvae on grasses in these quadrats to determine the larval densities in February, March, April and May, 2007. I recorded the daily maximum and minimum temperatures at two points at site A (points A and B; Fig. 1) from early February until early April, 2007.

Development of larvae in the spring

To determine whether overwintered larvae can complete their development under outdoor

conditions, I collected 20 larvae in the field of FFPRI outside the above mentioned quadrats in early April, 2007. They were reared individually in transparent cups (125×125 mm at the base, 57 mm height) which were placed in a wire-mesh cage (4 m^2×2.5 m in height) in the field. *I. cylindrica* leaves were provided as food. The development of immatures was checked every 2–3 days.

Monitoring of adults in the field

To determine the adult emergence season of the overwintering generation under natural conditions, three Malaise traps were set along the wall of the building in the grassland near site A on April 10, 2007. The traps were checked every week through July 2, 2007.

Results

I found about ten small larvae in early December of 2006 for the first time in quadrat A-1. On that occasion, the larval density was unknown. In early February of 2007, 24 larvae of various sizes were found in quadrat A-1 (Table 1, Figs 5 and 6). Most of the larval nests were found on grasses growing within 10 cm from the building wall. A few larval nests were even attached to the wall.

During warm daytimes, some larvae emerged from their nests and actively crawled on the grasses. In early March and early April, 37 and nine larvae were found in quadrat A-1, respectively. In quadrats A-2 and B, only a few larvae were found in February, March and April. No larvae were found in quadrat C. In early May, I could not find any larvae in any of the quadrats. In quadrat A-1, many green regrowths of *I. cylindrica* lived throughout the winter (Fig. 2), but in the other quadrats, most of them died and only a few discolored leaves survived.

The temperatures were higher at point A (overwintering site) than at point B (air temperatures: Fig. 7). Even in February, the daily maximum temperature at point A reached approximately 30°C on sunny days whereas the minimum fell to near 0°C. On cloudy and rainy days, the differences in temperature between the two points were smaller than on sunny days. No snowfall was observed throughout the winter in and around the present field.

Table 1. State of food plants and density of overwintering larvae of *P. mathias* in each qudrat.

Quadrat		A-1	A-2	B	C
Area censused (m)		18.5×0.8	18.5×4.0	18.5×4.0	18.5×4.0
Season when grass was mowed in 2006		late September, grass was carried out of the grassland	ate September, grass was carried out of the grassland	mid September, grass was left in the grassland	late September, grass was left in the grassland
State of *I. cylindrica* in early February, 2007		20–25 cm in height, high density, many green regrowths lived	10–15 cm in height, high density, most of the regrowths died and a few discolored leaves survived	70–80 cm in height, high density, most of the regrowths died and a few discolored leaves survived	40–50 cm in height, low density, most of the regrowths died and a few discolored leaves survived
No. larvae found (density; per m^2)	2–9, Feb.	24 (1.62)	0 (0)	2 (0.03)	0 (0)[a)]
	1, Mar.	37 (2.50)[b)]	1 (0.01)	1 (0.01)	0 (0)
	2, Apr.	9 (0.61)	1 (0.01)	2 (0.03)	0 (0)
	7, May	0 (0)	0 (0)	0 (0)	0 (0)

[a)] One dead larva was found.
[b)] Two dead larvae were found.

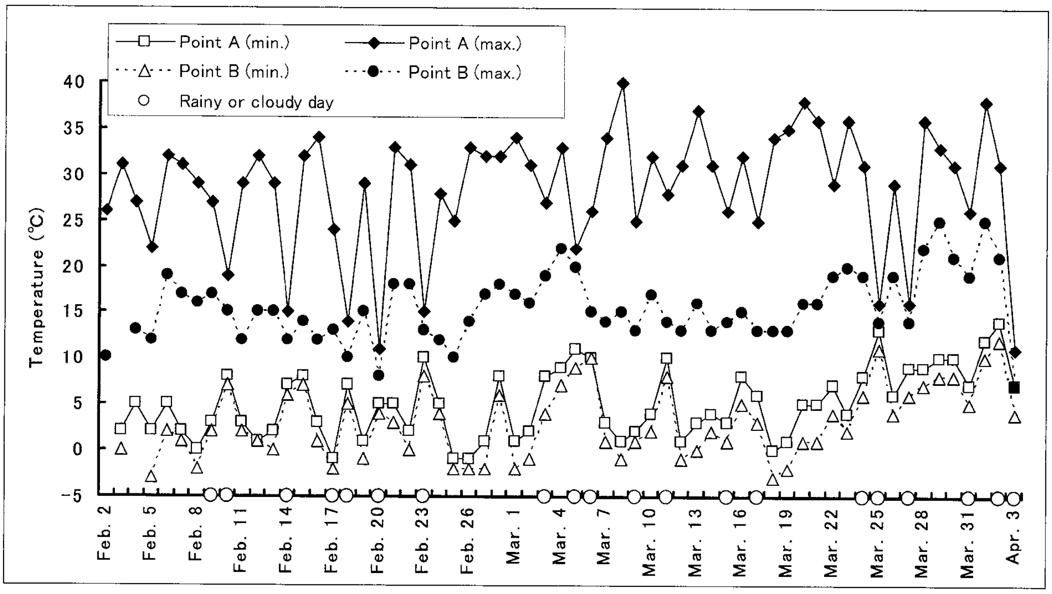


Fig. 7. Daily maximum and minimum temperatures at points A and B from early February to early April, 2007.

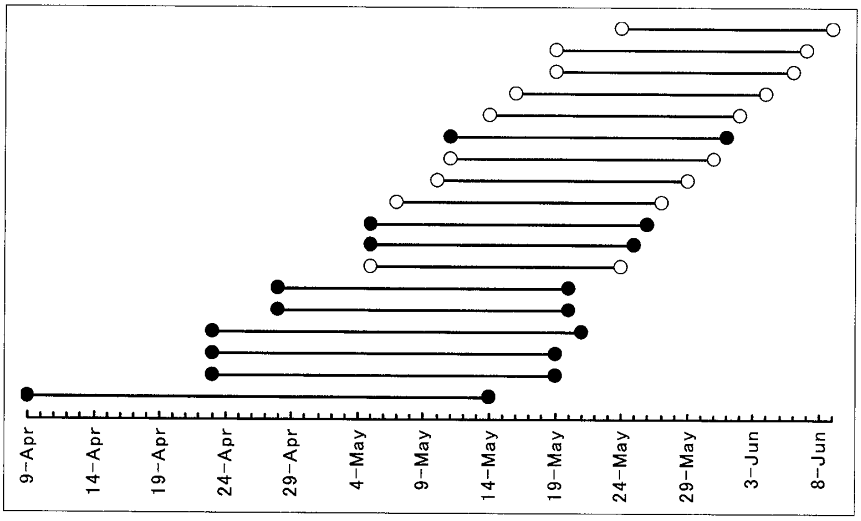


Fig. 8. Pupal periods of *Pelopidas mathias* larvae collected in early April 2007 under quasi-natural conditions (field cage). Each line with symbols denotes an individual. Black and white circles mean male and female, respectively. Two larvae which died or escaped were excluded.

Twenty larvae collected in the field in early April included various instars. Eighteen of them pupated in the field cage. Seventeen of them molted once or not at all before pupation and one larva molted three times. Pupation and adult emergence occurred in early April–late May and mid May–early June, respectively (Fig. 8). When the larvae pupated in April, the pupal period was 22–35 days, but it was 16–21 days when the pupation took place in May. Males emerged earlier in the season than females. One female adult was caught in mid May in the field with a Malaise trap.

Discussion

In Ibaraki Prefecture, we can usually observe *P. mathias* adults from June–July to October–November (Ibaraki Shinbun Co., 1985; Inoue, 2001, 2007), but the details of overwintering

Table 2. Monthly mean air temperatures (°C) from October to April in Mito and Tsukuba (Tateno), Ibaraki Prefecture, central Japan.

	October		November		December		January		February		March		April	
	Av.[1]	2006	Av.	2006	Av.	2006	Av.	2007	Av.	2007	Av.	2007	Av.	2007
Mito	15.7	17.1	10.2	11.4	5.1	6.6	2.8	4.6	3.3	5.8	6.3	8.1	11.8	11.6
Tsukuba	15.6	17.3	9.8	11.6	4.5	6.4	2.3	4.5	3.2	6.0	6.5	8.6	12.3	11.9

[1] Average of 1971–2000.

of the species in this prefecture have not been clarified. In Tochigi Prefecture, it is assumed that migrants lay eggs in June–July and that new generations are produced in summer-autumn, but that they cannot pass the winter there (Kuzuya, 2000). From the present observations, it seems that larvae of *P. mathias* are able to pass the winter in inland fields (away from coastal areas) of northern Kanto, and the emergence of adults successfully takes place in May–June, at least when the winter is mild.

Larval diapause of *P. mathias* is terminated by early December (Ishii, 1980). The survival rate of *P. mathias* during winter is lower than that of *P. guttata*, and *P. mathias* is more sensitive to low temperature than *P. guttata* (Nakasuji *at al.*, 1981). The mean air temperature at Ibaraki (Mito and Tsukuba (Tateno)) during the present study is approximately 2–3 degrees Celsius higher than the average (Mito local meteorological observatory; http://www.tokyo-jma.go.jp/home/mito/) (Table 2). The mild winter may contribute to successful overwintering after termination of diapause. Further studies are needed to investigate whether larvae can survive normal or cooler winters.

Fukuda *et al.* (1984) speculated that overwintering larvae might be the middle (third and fourth) instars. Results of the present study suggest that the instar stage of overwintering larvae is more variable, because larvae collected in early April molted zero to three times before pupation.

Larvae may pass the winter more easily on grasses growing near buildings than on those growing in open land because host leaves keep a better condition during the winter and the temperature is higher in such an environment. Omori (1933) pointed out a similar result with the hibernation of the rice skipper, *Parnara guttata*. In late autumn and winter, pupae of the ladybird, *Coccinella septempunctata brucki* frequently attaches to substances such as stones or wood that have been discarded in sunny places, and the heat from warmed substances makes it possible for adults to emerge from pupae even in winter (Sakuratani *et al.*, 1991; Sakuratani and Miwa, 2005). Larvae of *P. mathias* may also develop by receiving heat from warmed substances such as a concrete wall even in mid-winter.

Beck (1983) showed that developmental responses to thermoperiods (daily cycles of temperature) vary among different insect species. In some cases, developmental periods are shortened by thermoperiods (*e. g.* Yamashiro *et al.*, 1998). For example, in butterflies, the developmental period (egg to adult emergence) of *Narathura bazalus* reared under fluctuating temperatures was significantly shorter than that under constant temperatures, especially when the rearing temperature conditions were relatively low (Aso *et al.*, 2006).

The temperatures recorded in the present study at point A may have been higher than those inside the larval nests which were made of living grass leaves. At the overwintering site that was exposed to the direct rays of the sun, however, *P. mathias* larvae may have been exposed to a rather wide range of diurnal temperatures which occasionally reached 30 degrees Celsius. In order to understand physiological aspects during hibernation, we must study the effect of thermoperiods on the larval development of *P. mathias* in the future.

Acknowledgment

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摘　　要

関東地方北部におけるチャバネセセリ幼虫の越冬に関する予備的研究 (井上大成)

2006–2007年にかけての冬に, 茨城県つくば市でチャバネセセリの越冬幼虫を観察した. 幼虫の密度は, 建物の南側の壁に近い草地で高かった. ここではチガヤは冬の間緑色を保っており, 幼虫は暖かい日中には活発に活動していた. 直射日光の当たる建物の南側の越冬場所では, 2月には日最低温度は0°C近くまで下がったが, 晴れた日の最高温度は30°C前後にも達した. 4月に野外から採集され網室で飼育された幼虫は, 4月上旬–5月下旬に蛹化し, 5月中旬–6月上旬に羽化した. 幼虫は蛹化前に0–3回脱皮した。蛹期間は4月に蛹化した場合には22–35日で, 5月に蛹化した場合には16–21日だった. また, 野外の壁際の草地に設置したマレーズトラップでは5月中旬に雌成虫1匹が捕獲された. チャバネセセリは北関東の内陸でも, 少なくとも暖冬の時には野外越冬していることが明らかになった.

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